REMARKS

There are now pending in this application Claims 1-28. Claims 1, 11, 22, 27 and 28 are independent. Claims 27 and 28 are newly-added. No claims have been cancelled.

In view of the above amendments and the following remarks, favorable reconsideration and allowance of the above application is respectfully sought.

Preliminarily, Applicant requests correction of the form PTO-892 attached to Paper No. 7. In that document, the U.S. patent to Markle is listed as No. 5,530,565 but the correct number is 4,530,565. Reissuance of a new PTO-892 is requested.

There is also accompanying this Amendment a Request for Permission to Amend the Drawings. This Request merely seeks to address minor informalities in the drawings and, with respect to Figure 14, change the language so that it more closely parallels that of the claims. Favorable consideration thereon is respectfully sought.

Applicant's invention as feature in independent Claims 1 and 11 is directed to an illumination optical system in which the luminous intensity distribution converting optical system serves to convert an illuminance distribution of a lamp image to a luminous intensity distribution on a predetermined plane. That plane may in fact be the light entrance surface of the light transmitting element. In order to assure that the

illuminance distribution of the lamp image is converted to a luminous intensity distribution on a predetermined plane, the lamp image and the predetermined plane should be placed to satisfy an optical Fourier transform relation, by means of the luminous intensity distribution converting optical system.

Each of Claims 1 and 11 stands rejected under 35 U.S.C. § 102 as being anticipated by any one of Nagayama, Ohta or Forkner, et al. The rejections are respectfully traversed.

Nagayama is directed to an illumination optical system and an alignment apparatus suitable for reticle alignment in the projection exposure apparatus. Nagayama features in Figure 1 a lens system 302 which functions to form a light source image at an incident end of the optical fiber 303 (see, col. 1, lns. 32-34). Thus, it is evident that the lens system 302 merely functions to re-image a lamp image formed at the focal point of the elliptical mirror 301 at the incident end of the optical fiber 303. It does not serve to place the lamp image and the predetermined plane (the incident end of the optical fiber 303) in an optical Fourier transform relation.

In Nagayama, the illuminance distribution of the lamp image formed at the focal point of the elliptical mirror 301 would not be transformed to a luminous intensity distribution at the incident end of the optical fiber 303. Thus, the lens system

302 of Nagayama does not correspond to the luminous intensity distribution converting optical system of the present invention.

Moreover, the embodiments of Nagayama are disclosed in connection with use with an excimer laser as its light source and do not feature a lamp as now recited in the Claims 1 and 11 of the present application. Thus, in addition to the above-discussed reasons, Nagayama also fails to teach or suggest Applicant's invention because it does not feature a lamp image as required by Claims 1 and 11.

For the foregoing reasons, Applicant respectfully submits that each of independent Claims 1 and 11 is patentable over Nagayama.

Ohta is directed to an illuminating apparatus and features in Figure 6 two sets of condenser lens systems which function to form a light source image on a light entrance surface of a multi-beam forming optical element (col. 6, lns. 4-10). Consequently, the lamp image and the predetermined plane (i.e., the light entrance surface of the multi-beam forming optical element 5') are placed at the same position. As a result, it is evident that the condenser lens systems 22 or 23 do not function to convert an illuminance distribution of the lamp image to a luminous intensity distribution on a predetermined plane. Thus, the structure of Ohta does not correspond to the luminance

intensity distribution converting optical system as recited in Claims 1 and 11 of the present application.

Forkner, et al. is directed to an optical fiber coupling system using segmented lenses. Upon examination of the disclosure of that reference, and particularly by tracing the light paths, it appears that the source of illumination 312 is disposed at one focal point of an elliptical mirror while a light entrance face of an output fiber is placed at the other focal point. In this type of structure, an image of the source of illumination is formed at the light entrance face of the output fiber and as a consequence the light image and the predetermined plane (i.e., output fiber 322 or 522) are placed at the same position. Thus, the elliptical mirror of Forkner, et al. does not function to convert an illuminance distribution of the lamp image to a luminous intensity distribution on a predetermined plane and therefore does not correspond to the claimed luminous intensity distribution converting optical system as recited in Claims 1 and 11.

For the foregoing reasons, Applicant respectfully submits that each of independent Claims 1 and 11 is patentable over the applied art of record. Favorable reconsideration and allowance of those claims is respectfully sought.

New Claims 27 and 28 incorporate the salient features of independent Claims 1 and 11, respectively. Accordingly, each

of Claims 27 and 28 is believed patentable over the art of record for reasons noted above with respect to Claims 1 and 11.

Applicant's invention as featured in independent Claim 22 is directed to an illumination optical system for use in an exposure apparatus for illuminating a mask having a pattern formed thereon and for projecting the pattern onto a substrate by projection exposure. The luminous intensity distribution converting optical system serves to convert a luminous intensity distribution of plural light fluxes to an illuminance distribution on a predetermined plane, which may be the light entrance surface of the light transmitting element. In addition, there is provided a light collecting optical system for defining an illumination region on the mask by use of a light from the light transmitting element.

Nagayama does not in Applicant's view teach an illumination optical system for illuminating a mask having a pattern formed thereon. As such, Nagayama does not teach or suggest the invention as recited in Claim 22 which requires an illumination optical system having a light collecting optical system for defining an illumination region on the mask by use of the light from the light transmitting element for illumination of the mask pattern.

Ohta relates to plural light fluxes which are instant on the multi-beam forming optical system 5' at different angles.

However, after this multi-beam forming optical system 5', there is no total reflection type light transmitting element. Accordingly, in Ohta there is no luminance intensity distribution converting optical system affective to convert the luminous intensity distribution of plural light fluxes to an illuminance distribution on the light entrance surface of a total reflection type light transmitting element.

Forkner, et al. fails to teach or suggest an optical system on which plural light fluxes are incident at different angles. Accordingly, Forkner, et al. does not teach or suggest a luminous intensity distribution converting optical system affective to convert the luminous intensity distribution of plural light fluxes to an illuminance distribution on a predetermined plane.

For the foregoing reasons, Applicant respectfully submits that independent Claim 22 is patentable over each of the applied references.

The remaining claims not heretofore discussed are dependent claims which depend from one of the above-discussed independent claims. Accordingly, each of these claims is patentable over the art of record for reasons noted above with respect to the independent claims. In addition, each recite features of the invention still further distinguishing it from

the applied art. Favorable and independent consideration thereof is respectfully sought.

Applicant respectfully submits that all outstanding matters in the above application have been addressed and that this application is in condition for allowance. Favorable reconsideration and early passage to issue of the above application are respectfully sought.

Applicant's undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,

Attorney for Applicant
Lawrence A. Stahl
Registration No. 30,110

FITZPATRICK, CELLA, HARPER & SCINTO
30 Rockefeller Plaza
New York, New York 10112-3801
Facsimile: (212) 218-2200

LAS:eyw

Application No.: 09/342,210
Attorney Docket No.: 684.2861

MARKED-UP CLAIM SHEET

1. (Amended) An illumination optical system, comprising:

a luminous intensity distribution converting optical system for converting an illuminance distribution of a [light source] lamp image into a luminous intensity distribution upon a predetermined plane;

a total reflection type light transmitting element having its light entrance surface disposed substantially in coincidence with the predetermined plane; and

a light collecting optical system for defining an illumination region upon a surface to be illuminated, by use of light from said light transmitting element.

2. (Amended) An illumination optical system according to Claim 1, wherein the illuminance distribution of the [light source] lamp image has an intensity which is higher at a portion adjacent to an optical axis than the intensity at a peripheral portion thereof.

3. (Amended) An illumination optical system according to Claim 1, further comprising a [light source] lamp, and [light source] lamp image forming means for forming the [light source] lamp image by use of light from the [light source] lamp.

4. (Amended) An illumination optical system according to Claim 3, wherein said [light source] lamp image forming means includes an elliptical mirror having a focal point whereat the [light source] lamp is disposed, and wherein the [light source] lamp image is formed at another focal point of said mirror.

5. (Amended) An illumination optical system according to Claim 3, wherein the [light source] lamp comprises a Hg lamp.

6. (Amended) An illumination optical system according to Claim 1, said converting optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens unit is disposed substantially in coincidence with the [light source] lamp image

while an exit pupil of the second lens unit is disposed substantially in coincidence with the predetermined plane.

7. (Amended) An illumination optical system according to Claim 1, wherein said converting optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the [light source] lamp image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.

8. (Amended) An illumination optical system according to Claim 1, wherein said converting optical system includes fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the [light source] lamp image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.

11. (Amended) An illumination optical system, comprising:

a luminous intensity distribution converting optical system for converting an illuminance distribution of a [light source] lamp image into a luminous intensity distribution upon a predetermined plane;

an optical fiber bundle having its light entrance surface disposed substantially in coincidence with the predetermined plane; and

a light collecting optical system for defining an illumination region upon a surface to be illuminated, by use of light from said optical fiber bundle.

12. (Amended) An illumination optical system according to Claim 11, wherein the illuminance distribution of the [light source] lamp image has an intensity which is higher at a portion adjacent to an optical axis than the intensity at a peripheral portion thereof.

13. (Amended) An illumination optical system according to Claim 11, further comprising a [light source] lamp, and [light source] lamp image forming means for forming the [light source] lamp image by use of light from the [light source] lamp.

14. (Amended) An illumination optical system according to Claim 13, wherein said [light source] lamp image forming means includes an elliptical mirror having a focal point whereat the [light source] lamp is disposed, and wherein the [light source] lamp image is formed at another focal point of said mirror.

15. (Amended) An illumination optical system according to Claim 13, wherein the [light source] lamp comprises a Hg lamp.

16. (Amended) An illumination optical system according to Claim 11, said converting optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens units is disposed substantially in coincidence with the [light source] lamp image while an exit pupil of the second lens unit is disposed substantially in coincidence with the predetermined plane.

17. (Amended) An illumination optical system according to Claim 11, wherein said converting optical system includes an optical rod and a lens unit, wherein a light entrance

surface of the optical rod is disposed substantially in coincidence with the [light source] lamp image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.

18. (Amended) An illumination optical system according to Claim 11, wherein said converting optical system includes a fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the [light source] lamp image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.

22. (Amended) An illumination optical system for use in an exposure apparatus for illuminating a mask having a pattern formed thereon and for projecting the pattern onto a substrate by projection exposure, said illumination optical system, comprising:

a luminous intensity distribution converting optical system for converting a luminous intensity distribution of plural light fluxes having different incidence angles into an illuminance distribution upon a predetermined plane;

a total reflection type light transmitting element having its light entrance surface disposed substantially in coincidence with the predetermined plane; and

a light collecting optical system for defining an illumination region upon <u>the mask</u> [a surface to be illuminated], by use of light from said light transmitting element.

MARKED-UP SPECIFICATION

Please substitute the paragraph starting at page 19, line 8 and ending at line 21. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--Figure 15 is a schematic view for explaining a sixth embodiment of the present invention. This embodiment is directed to a system in which an illumination optical system according to any one of the first to fifth embodiments is incorporated into an exposure apparatus for manufacture of semiconductor devices. In Figure 15, denoted at 30 is an illumination optical system such as described above. It functions to illuminate a mask [31] 131 uniformly, which is placed at an imaging plane 6 or a plane optically conjugate therewith. Denoted at [32] 132 is a projection optical system for lithographically transferring a circuit pattern, formed on the mask [31] 131 onto a wafer [32] which is coated with a resist.--.

Please substitute the paragraph starting at page 19, line 22 and ending on page 20, line 1. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--In this embodiment, the projection optical system [32] 132 may comprise a unit magnification type mirror scann9ing optical system such as shown in Figure 1, or it may comprise a stepper reduction projection lens. Alternatively, this embodiment may be applied to an illumination optical system for a reduction type step-and-scan exposure apparatus (scanner).--.

Please substitute the paragraph starting at page 20, line 2 and ending at line 27. A marked-up copy of this paragraph, showing the changes made thereto, is attached.

--When an illumination optical system according to the present invention is incorporated into an exposure apparatus such as described above, the following advantageous effects are obtainable. The luminous intensity distribution of illumination light such as shown in Figure 9 is emitted from the illumination optical system while the distribution being preserved, and it illuminates the mask [31] 131 surface. Then, the light passes through the mask [31] 131 surface (while a portion of the light is transformed into diffractive light), and it reaches the pupil plane 33 of the projection optical system [32] 132. Upon this pupil plane 33, there is produced an illuminance distribution directly corresponding to the luminous intensity distribution at the mask [31] 131 surface. Usually, this distribution is called

an effective light source, and it is well know that the shape of this effective light source largely affects the resolution performance in pattern printing. If the distribution has a Gaussian shape (small sigma) wherein the light intensity is large at a portion close to the optical axis (NA = 0) of the projection optical system [32] 132, there is a tendency that, depending on the pattern, the resolution depth is expanded. Of course, the effect of high illumination efficiency through the illumination optical system 30 is held.--.